# *Some Biological Indicators of Marine Environmental Degradation*


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*ABSTRACT*

Evidence is accumulating that marine organisms can provide clues to the extent of degradation of inshore waters resulting from human activity. The warning signs include mass mortalities, changes in species composition, and increasing occurrences of diseases and abnormalities in fish and shellfish. A critical present need exists for more information which will enable us to distinguish man-induced phenomena from natural phenomena.


As the human species, in the midst of a global population explosion of unprecedented proportions, begins to make harmful impact on the shallow edges of the seas, the marine organisms whose immediate surroundings are being degraded attempt to communicate their displeasure and discomfiture. The methods of communication, if we are perceptive enough to be aware of them and to interpret them, can provide us with an early warning system about increasing levels of environmental contamination. Some elements of the system are undoubtedly subtle and may well escape observation; others are relatively overt and obvious.

I hope, in this paper, to identify some of the more obvious biological warning signs of environmental damage in inshore marine areas—itemizing some of the forms in which the protests manifest themselves and indicating the kinds of research we should do to best interpret the signals we are receiving. Some of the following material is frankly speculative; the rest is based firmly on the very thin layer of specific information now available to us. The thesis to be defended is that damage is being done to inshore marine environments and populations, and that responses of marine organisms can give us clues to the nature and extent of that damage.

## Mass Mortality

Probably the best, and certainly one of the most apparent, indications of environmental degradation, whether by toxic or infective material, or chemical or thermal addition, is mass mortality, usually of localized nature in areas of heaviest contamination. Examples of this phenomenon are becoming increasingly abundant. One of the most recent and the most devastating concerns repeated and extensive mortalities of fish and shellfish in Escambia Bay in northern Florida—a bay grossly polluted, principally by the poorly controlled effluent of several large chemical production plants. Beginning in 1967, summer fish kills have occurred there with increasing frequency and severity, and in 1971 over 90% of the oyster population of that Bay was destroyed within the space of a few days. Fish mortalities have been attributed to toxic chemicals dumped in the Bay, and to low oxygen levels resulting from massive eutrophication. Mortalities of fish and shellfish have also been character-

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istic of other chemically polluted bays such as Raritan Bay in New Jersey.

It is important to note, though, that mass mortalities due to natural causes are probably more abundant and more significant than those caused by human activities. Man has merely added another group of stress factors.

### Changes in Species Composition

The next best indication of environmental degradation takes the form of drastic or subtle changes in the flora and fauna of an area, either in terms of reduced abundance or in disappearance of certain species. Generally such changes can be summarized in 3 categories:

a) the decline and disappearance of species valuable as food or sport for man, and their replacement by rough species with lower value to man;

b) the development of a monotonous fauna consisting of fewer and more resistant species (such as certain worms) able to tolerate low oxygen conditions; and

c) changes in the algal flora, often resulting in appearance of blooms (often as red tides); and the predominance of blue-green and brown algae, the latter often occurring as a scum on inshore bottoms.

Occasionally, environmental changes may also result in population explosions of certain animal species which are normally inconspicuous parts of the fauna. An invasion of sea urchins in a sector of Florida coast previously affected by a massive red tide outbreak in the summer of 1971 is a most recent example. An earlier invasion by sea urchins occurred several years ago in kelp beds on the California coast.

Several reports (Raney, 1952; Chittenden, 1971) point to habitat destruction by industrial and domestic pollution as a cause for drastic decline of striped bass and other anadromous fishes from certain Middle Atlantic estuaries, particularly the lower Delaware River.

An interesting recent report by Glover *et al*. (1971) indicates that over the past 22 years there has been a progressive decline in the abundance of many species and in the biomass of zooplankton in parts of the North Atlantic, together with a shortened season of biological activity. Among the many variables suggested as potential causes was the depressive affect of pesticides on phytoplankton photosynthesis. Such large-scale, long-term observations in the sea are all to rare, but they may indicate major derangements of man-made origin.

### Abnormalities and Diseases

Another, and a more recently identified indicator of environmental contamination and degradation is the appearance of unusual or increased frequencies of abnormalities and diseases in eggs, larvae, juveniles and adults of estuarine and marine species. Documentation of this phenomenon is still very incomplete but is adequate enough even at present to suggest that it will become a powerful tool in assessing the extent of damage to the marine environment caused by effluvia of human civilization. Some of the varied forms include:

a) an apparent increase in observations of tumors and abnormal growths (Fig. 1) on fish taken from grossly polluted waters (information is available from California and Florida waters);

b) appearance of fin and skin erosion—called "fin rot"—(Fig. 2) in fish from polluted waters (information is available from waters of the New York Bight, California and Florida);

c) erosion of the exoskeletal projections of Crustacea taken from polluted waters (information is available from New York Bight waters);

d) increased frequency of fungus infections of eggs carried by Crustacea, in areas of gross pollution (Sheader and Chia, 1970);

e) growth abnormalities in certain sessile invertebrates associated with chemical contaminants (Powell *et al*., 1970); and

f) appearance of lymphocystis (a virus disease of fish) in certain Gulf of Mexico estuaries with high pollution loads, and absence of the disease in certain other less polluted areas (Christmas and Howse, 1970).

Fig. 1.–Abnormal growths on mullet (above) and snapper (below) taken from Biscayne Bay, Florida.

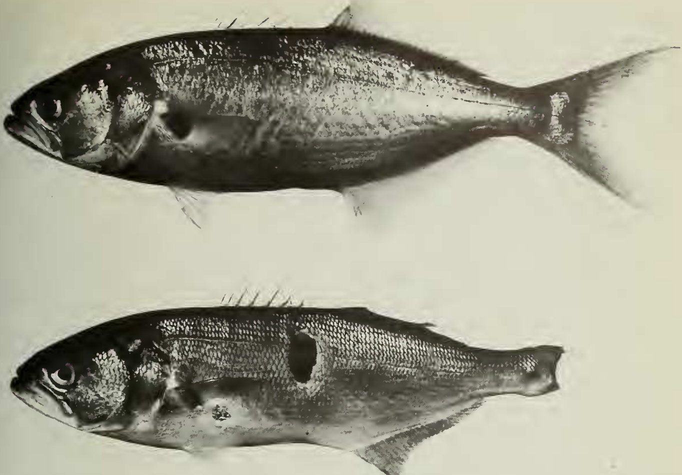

Fig. 2.–Normal (above) and fin rot infected (below) bluefish from the New York Bight area (photographs by Malcolm J. Silverman, NMFS).

Several of these conditions (such as fin rot and lymphocystis) could result from increasing infection pressure by facultative pathogens, possibly combined with increasing environmental stress imposed by pollutants. Domestic and industrial effluents containing carcinogenic compounds or viruses introduce additional environmental hazards for estuarine and inshore species.

Egg and larval abnormalities may also serve as sensitive indicators of environmental pollution. Sheader and Chia (1970), reporting on a study of a bay on the coast of Britain, found that amphipods (*Marinogammarus obtusatus*) tended to be more abundant near a sewer effluent, and those nearest the effluent carried a much higher percentage of diseased eggs than those remote from the effluent (27% of a sample of 92 mature females versus less than 1% of females from other parts of the bay). The authors suggested that microorganisms in the sewage may produce egg infections directly or that low salinities near effluents could kill the eggs or render them more susceptible to infection.

Crustacean and molluscan larvae can serve as extremely sensitive indicators of environmental degradation. Use of larvae as bioassay organisms has a significant history on the west coast in pulp mill pollution studies (Woelke, 1967; 1968), and is receiving increasing attention on the east coast as well—particularly at the Milford (Connecticut) laboratory of the National Marine Fisheries Service, where current studies concern the effects of heavy metals on survival and development of eggs and larvae.

### Speculations

The signals, then, are present, if we are observant or perceptive enough to recognize and interpret them. I am particularly intrigued by the possible role that viruses and bacteria may play in contaminated coastal waters. Allowing for some speculation, certain of the viruses of human origin may possibly be pathogenic to marine animals in their natural or mutated state. Interesting recent reports (Farley, 1969) of very-high prevalences of neoplastic disease in shellfish, and observations of tumors in fish from polluted zones, offer some basis for such a possibility. Viruses which might be benign or hidden in humans could produce quite different effects in marine animals. Evidence exists, for example, that fish cell lines are susceptible to a wide array of viruses of homoiothermic origin (Solis and Mora, 1970). Carrying speculation one step further, it is conceivable that viruses (and bacteria) of human origin may be able to multiply in certain marine species without causing an observable effect, and then serve as a reservoir of infection for humans who enter the marine environment or who eat the animals. This might result, just as an example, in an increase in superficial skin warts or other skin infections among skin divers or bathers who frequent grossly polluted waters.

I have already suggested that bacteria of human origin may be facultatively pathogenic in stressed populations of marine animals, where they may produce effects unlike those produced (if any) in normal hosts. Organic loads from sewer effluents and sludge dumping could promote bacterial growth, including that of heterotrophic marine or estuarine bacterial species, leading to tremendous infection pressure on fish and other animals by such facultative microorganisms. The suggestion has been made, and some limited evidence exists (Janssen and Meyers, 1968), that certain bacterial pathogens of humans are able to infect fish. Antibodies against such pathogens were demonstrated in fish from polluted waters, but not in those from relatively clean waters. This work needs to be extended, but it does suggest that antibodies in fish may be used as sensitive indicators of pollution, whether the fish become grossly infected or not. There is also the likelihood that populations of bacteria such as the vibrios and pseudomonads, which may be pathogenic for humans who enter marine waters or eat the animals, may be enormously expanded by the availability of rich organic soups in outfall and sludge dumping areas.

In terms of impact on living marine resources, it seems reasonable to expect that the synergistic, cumulative effect of pollutants may well exceed the mere summation of individual effects. Thus, for example, chemical erosion of the mucus of a fish may expose it to invasion by facultative microorganisms; or modification of the physiology of a marine animal by high levels of heavy metals may lower its resistance to such facultative microorganisms.

## Suggested Areas for Research

With the present climate of increasing concern about the state of well-being of the planet and its continued ability to support life as we know it, the opportunity to conduct relevant research is enhanced. Some of the indications of marine environmental damage considered in this paper are just that–indications–and so require substantial study. Among the research areas which need augmentation are the following:

1. Firmer data should be obtained linking decline or disappearance of certain species to pollution (at present, alternative causes could be argued). This will require both field and experimental studies and will require careful continued assessment of abundance of such species.

2. Broad trends in ocean productivity should be examined and a search made for causes of any changes detected. The analysis of copepod abundance by Glover *et al.* (1972) is an excellent example of what should be done regionally and locally, as well as on a broader scale. Fish and benthic organisms should be examined in the same way.

3. Bioassay work, especially that using larvae and juveniles of fish and invertebrates, should be expanded. Since larval survival to a large extent determines abundance of adults, and since larvae are remarkably sensitive to many environmental contaminants, such studies have far-reaching significance. Studies should include consideration of growth rates, metamorphosis, and abnormalities, as well as mere survival.

4. Tumors and neoplasms of marine fish and shellfish should be carefully examined, and the role of environmental carcinogens introduced by man as well as that of viruses should be determined.

5. Increasing reports of localized and widespread red tides should be studied in relation to pollution levels and other man-induced environmental changes.

6. The non-commercial marine animals should be scrutinized for changes in species composition and for abnormalities indicative of environmental stress. This is particularly needed in coastal areas with gross contamination.

7. Specific and obvious leads—such as the appearance of fin rot disease in fish from polluted waters, and the occurrence of antibodies in fish to human pathogens—should be exploited vigorously.

## Conclusion

These indications can be considered as small, scarcely audible voices of protest and warning—protest against effluvia from the land that threatens the existence and well-being of coastal species, and warning of possibly more serious disruption of marine ecosystems if the degrading processes persist. Running throughout is also a thread of increasing danger to humans who enter the corrupted marine waters, or who consume products from that source.

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